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Modeling of titanium oxide nanostructures formation process by local anodic oxidation

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The development of components of modern electronics, in particular memristor structures for resistive memory (RRAM) elements, requires the application of new methods for the formation of nanoscale structures that possess precise precision and high reproducibility. One of such methods is the method of local anodic oxidation (LAO) allowing to form titanium oxide nanostructures (ONS) that exhibit a memristor effect without carrying out an additional electroforming operation [1-2]. However, the LAO process is still insufficiently studied, so the actual task is the development of a mathematical model that allows to calculate the geometric dimensions of the titanium ONS on the formation process.

Since the LAO process is associated with the generation and transfer of oxygen ions in the probe-air-oxide-substrate system and subsequent oxidation of the substrate, it is necessary to calculate the oxygen ion flux at each point of the substrate surface, for this it is necessary to solve the system of Poisson and continuity equations:

$$\begin{cases} \nabla(\varepsilon\nabla\varphi) = -\rho(N), \\ \nabla(-\mu N\nabla\varphi + D\nabla N) = R(\varphi). \end{cases} \quad (1)$$

where ε is the dielectric constant, φ and N are the distribution of the electric potential and the concentration of oxygen ions in the system, ρ is the volume density of electrical charges, μ and D are the mobility and diffusion coefficient of oxygen ions, R is the generation rate of oxygen ions in air. As a result of the solution of this system of equations, it is possible to calculate the profile of the titanium ONS at each point of the surface throughout the entire LAO process (Fig. 1).

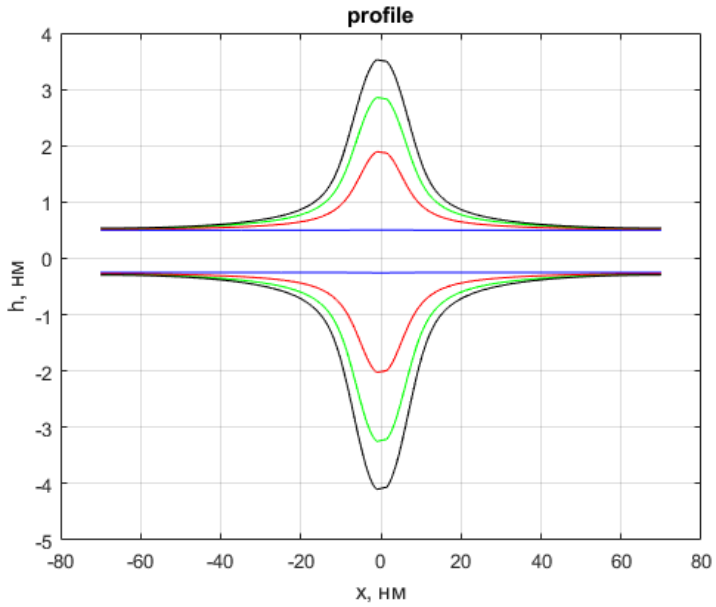

Figure 1. Titanium ONS profile on the various stages of the LAO.

The obtained results can be used in the development of technological processes for the fabrication of the RRAM element base based on titanium oxide nanostructures.

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2. V.I. Avilov, V.A. Smirnov, et al., *Materials Science and Engineering* **256**, 5 (2017).